Mikio ONO*: Chromosome number of *Scalesia* (Compositae), an endemic genus of the Galapagos Islands**

小野幹雄*: ガラパゴス群島特産属 *Scalesia* (キク科) の染色体数**

Introduction The genus *Scalesia* is known as one of the endemic genera of the Galapagos Islands, and is the largest genus among the vascular plants in the Islands. About the taxonomy of the genus, an excellent monograph was published by Howell[1] (1941), in which he accepted eighteen species in this genus, and recently Harling[2] (1963), mainly following Howell, redefined the circumscription of some species by adding new material. But no cytological data has been reported, perhaps because of difficulty to get material for such investigation. On the systematic position of the genus, it is accepted to be referred to the subtribe Helianthinae (Verbesininae)*** of the tribe Heliantheae, but the relationship to other genera within the subtribe is still uncertain. In the beginning of March, 1966, the author got a chance to visit some islands of the Galapagos on the way back from the Peruvian Andes, as a member of the botanical expedition sent by the University of Tokyo, and fortunately he could collect mature seeds of some species of *Scalesia*. These collected seeds were germinated and cultivated in greenhouse in Tokyo. The present paper is the results of cytological investigation upon these material and attempts to discuss the systematic relationship of the genus from the data of chromosome numbers.

Material and Methods Mature fruiting heads were collected from the following species at the following localities: *Scalesia affinis* Hook. fil., Academy Bay, Isla Santa Cruz; *S. pedunculata* Hook. fil. var. *Svensonii* Howell, near Bella Vista, Isla Santa Cruz; *S. pedunculata* Hook. fil. var. *parviflora* Howell, near the Wittmer's farm, Isla Floreana; *S. villosa* Stewart, Cormorant Bay, Isla Floreana.

The seeds were sown on vermiculite beds in July, 1966 and germinated after two weeks except *S. villosa* which did not germinate at all. Root tips of the

* Makino Herbarium, Tokyo Metropolitan University. 東京都立大学理学部牧野標本館.

** Contribution No. 17 from the Makino Herbarium of Tokyo Metropolitan University. Contribution No. 90 from the Charles Darwin Foundation for the Galapagos Isles.

*** In accordance with the present International Code of Botanical Nomenclature, it is better to call Helianthinae today.

seedlings were pretreated with 0.002 M 8-oxyquinoline for three hours, and fixed with 45% acetic acid for 30 minutes. After hydrolysed in 1N-HCl of 60°C for two min., the material were squashed and stained with acetic orcein.

The specimens, from which seeds were collected, were identified by the author during the stay at the herbarium of California Academy of Science, and are deposited in Makino Herbarium, Tokyo Metropolitan University (MAK).

Result and Discussion

1. *Scalesia affinis* Hook. fil.

The seeds were collected on the wayside to Darwin Station, Academy Bay of Isla Santa Cruz (Indefatigable Island). The somatic chromosome number is counted as 2n=68 (Fig. 1). Among the thirty-four pairs of chromosomes, twenty-six pairs have a median or sub-median constriction, but the rest eight pairs have sub-terminal constriction. So that the karyotype formula of this species can be expressed as K(n)= 34=26V+8J. The length of chromosomes are rather short and even the longest one is less than 5 μ long. Total length of sixty-eight chromosomes is approximately 200 μ (190–212 μ).

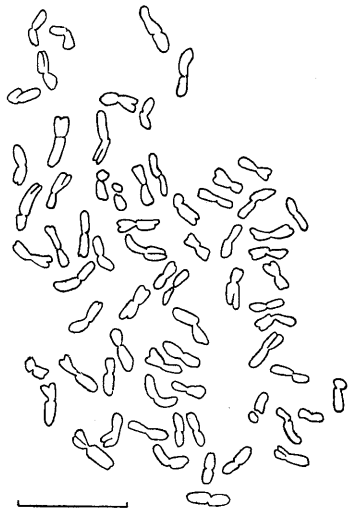

Fig. 1. ×ca. 1,450. The scale shows 10μ.

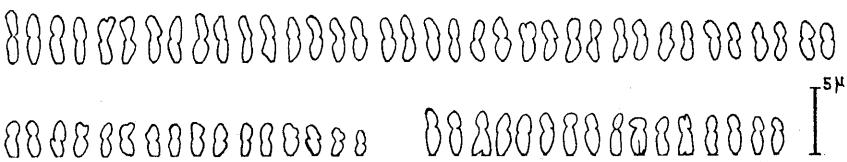

Fig. 2. The schematic figure of the karyotype of *S. affinis*.

2. *Scalesia pedunculata* Hook. fil.

2a. *S. pedunculata* Hook. fil. var. *Svensonii* Howell

This is one of the dominant species of the montane vegetation of the southern slope of the Santa Cruz Island, especially of the zone between 180 m and 280 m alt. (Itow[3] 1965). The seeds were collected from several tall trees near Bella Vista,

ca. 240 m alt.

The somatic chromosome number is 2n=68, as same as the former species. The karyotype is rather similar to that of the former species, namely eight pairs of the chromosomes have sub-terminal constriction and the other twenty-six pairs have median or sub-median ones. The karyotype formula is the same as that of *S. affinis*; n=34=26V+8J. Chromosome length is also short as in the former species (Fig. 3, 4).

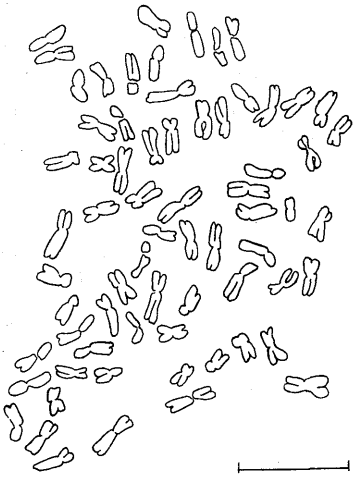

Fig. 3. ×ca. 1,450. The scale shows 10μ.

2b. *S. pedunculata* Hook. fil. var. *parviflora* Howell

The seeds of the var. *parviflora* were got from a big tree on the way from Black Beach to the Wittmer's farm. Some additional collections were made also on Mt. "Olympos" near the center of the island. Young trees grew densely, forming a pure forest on the slope of this mountain as well as near the "Pampa" (a small grassland near the Wittmer's farm), but the fruiting (or flowering) trees were rather rare.

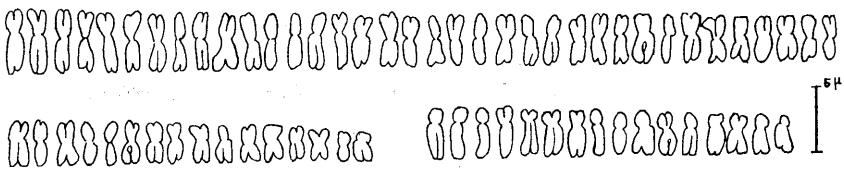

Fig. 4. The schematic figure of the karyotype of *S. pedunculata* var. *Svensonii*.

The chromosome number and karyotype of this variety is similar to that of the var. *Svensonii*, having 2n=68 chromosomes in a somatic cell. Out of thirty-four pairs of the chromosomes, eight pairs have sub-terminal constriction while the other pairs have all median or sub-median ones. The total length of chromosomes is more or less longer than that of var. *Svensonii*, but the difference is not considered to be significant. The karyotype formula is also K(n)=34=26V+8J (Fig. 5, 6).

To compare the karyotype of these species, the number of the chromosomes is

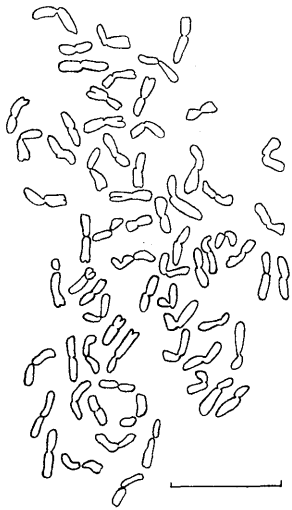

Fig. 5. ×ca. 1,450. The scale shows 10μ.

the same, and their size is also nearly alike within these three entities. Their karyotype formula can be shown as K(n)=34=26V+8J. This number (n=34) is considered to be induced from the basic number n=17, which is shown in several genera of the subtribe as mention later. The total length of chromosomes is approximately from 190 μ to 225 μ in these three entities.

As for the systematic position of the genus, *Scalesia* was first described by Arnott (in Lindley 1836) and referred to the Heliantheae, Heliopsideae of the classification of Lessing (1832), but five years later, Hooker and Arnott (1841) published again a description of the genus and remarked "A very distinct genus unlike any with which we are acquainted." (cf. Howell p. 222). In 1873 Bentham and Hooker fil.[4] fixed the position of *Scalesia*

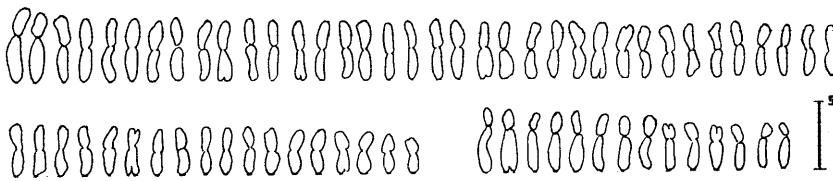

Fig. 6. The schematic figure of the karyotype of *S. pedunculata* var. *parviflora*.

between *Wulffia* and *Mirasolia* (at present *Tithonia* subgen. Mirasolia) in the subtribe Verbesininae of the tribe Helianthoideae. Hoffman[5] (1894) also referred the genus to the Heliantheae—Verbesininae (now called Helianthinae), but placed it between *Rudbeckia* and *Temnolepis* which is a monotypic genus of Madagascar. But according to Howell[1] *Tithonia* (now including *Mirasolia*) does not seem to stand so near to *Scalesia* as such Central or South American *Helianthus* group of genera as *Helianthus*, *Viguiera*, *Balsamorhiza* or *Gymnolomia*. Even to *Wulffia*, though recognizing its relationship to *Scalesia*, Howell denied the Bentham and Hooker's opinion that *Wulffia* might immediately precede *Scalesia*. He said "it is highly improbable that the relatively unvarying climber *Wulffia* gave rise to the highly diverse and variable series of shrubby and arborescent species in *Scalesia*

or *vice versa*", and he assumed that *Scalesia* and *Wulffia* might have a common ancestor which might well have resembled the present-day group of genera which center in *Wedelia* and *Aspilia*.

According to Harling[2], evidence of the correctness of including *Scalesia* in the Heliantheae is furnished by the embryological and palinological characters.

Concerning the number of chromosomes, very various numbers have been reported as the basic numbers of the tribe Heliantheae, namely x=4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 21. And even in the subtribe Helianthinae in which *Scalesia* belongs, such chromosome numbers have been counted as n=11, 12, 15, 16, 17, 18, 19, 21 and 34 (Turner, Ellison and King[6] 1961, Beaman and Turner[7] 1962, Turner and Flyr[8] 1966 etc.). As to the genera related to *Scalesia*, several species of *Tithonia* from Mexico and Central America including the species formerly referred to *Mirasolia*, have been reported to have all n=17 chromosomes (Heiser[9] 1948, Darlington and Wylie[10] 1955, Turner et al.[6], Turner, Powell and King[11] 1962, Turner and Flyr[8]). About *Wulffia* and *Wedelia*, though there are very few reports regarding their chromosome number, two species of Guatemalan *Wedelia* were reported to have n=11 and n=12 respectively (Turner, Powell and King[11]), while other two Brazilian species of *Wedelia* were counted to have n=20 and n=29±1 (Turner and Irvin[12] 1960). The only one report about *Wulffia*, which is a genus with only two species, was made by Turner and Irvin[12] (1960) on a Brazilian species *W. baccata* O. Ktz., and its chromosome number was counted as n=30±1.

In addition to them, the other Central and South American genera of the subtribe Helianthinae such as *Balsamorhiza*, *Helianthus*, *Rudbeckia*, *Viguiera*, *Gymnolomia* and *Aspilia*, that have been compared with *Scalesia* or *Tithonia* as mentioned above, have chromosomes as the following table;

Genera	Chromosome numbers (n)	Material	Authors
Balsamorhiza	19	w. N. America	Weber[13] 1946
Helianthus	(16), 17, 51	N. America	Heiser 1938 etc.
Rudbeckia	16, 19, 38	N. America	Battaglia[14] 1947
Tithonia (incl. *Mirasolia*)	17	Mexico, Guatemala	Heiser 1948 etc.
Viguiera	34	Mexico	Beaman & Turner 1962
Wedelia	11, 12, 20, 29±1	Guatemala, Brazil	Turner et al. 1962

Wulffia	30±1	Brazil	Turner & Irvin 1960
Gymnolomia	no data		
Aspilia	no data		
Scalesia	34	Galapagos Isls.	Ono

From the viewpoint of chromosome number, the genus *Scalesia*, although only two species were examined, seems to suggest some relationship with *Tithonia* and *Viguiera* having the same basic number, x=17. Though there is another genus *Helianthus* having the same basic number in the group (Darlington and Wylie[10]), it is difficult to consider the relationship between *Scalesia*, all species of which are shrubby or arborescent, and *Helianthus* in which all species are known as herbaceous. In habit, in other two genera *Tithonia* and *Viguiera*, there are several members of half-shrubby species respectively (Blake 1918[17], 1921[18]). On the other hand, an immediate relationship of the genus *Wedelia* or *Wulffia* to *Scalesia* is considered to be improbable from the data of chromosome number.

Based on the fact that chromosome number of *Scalesia* examined here are all 2n=68, the author assumes an occurrence of polyploidy within a certain continental ancestral group, which might have 2n=34 chromosomes as known in the recent *Tithonia* or *Viguiera*, in process of migration to the Galapagos Islands. More detailed investigation especially the karyotypic analysis about the Central and South American species of *Aspilia* and other genera of the *Helianthus* group as well as the other species of *Scalesia* is eagerly waited.

Acknowledgement The author wishes to express his cordial thanks to Prof. Fumio Maekawa of the University of Tokyo for his valuable advice and for his generasity of giving the chance to visit the Islands as the head of the botanical expedition to the Andes sent by his University, and he also thanks to Assist. Prof. Masami Mizushima, the curator of the Makino Herbarium of Tokyo Metropolitan University, for his criticism and encouragement throughout this study. The author's acknowledgement is also due to Dr. J. T. Howell, the curator of the Herbarium of the California Academy of Science for his kindness on identification of the specimen, and to Dr. R. Perry, the director of the Darwin Station of the Galapagos Islands who kindly gave the facilities to the author in his collecting trip.

References

1) Howell, J. T. Proc. Calif. Acad. Sci. Ser. 4, **22**: 222 (1941). 2) Harling, G.,

Acta. Horti Berg. **20**: 63 (1963). 3) Itow, S., Hikobia **4**: 318 (1965). 4) Bentham, G. and Hooker, J. D., Genera Plantarum, **2**, part 1, London (1873). 5) Hoffman, O., Compositae in Engler u. Prantl, Die naturl. Pfl.-fam. (1 Aufl.), IV-5, Leipzig (1894). 6) Turner, B. L., Ellison, W. L. and King, R. M., Amer. J. Bot. **48**: 219 (1961). 7) Beaman, J. H. and Turner, B. L., Rhodora **64**: 271 (1962). 8) Turner, B. L. and Flyr, D., Amer. J. Bot. **53**: 24 (1966). 9) Heiser, C. B., Bull. Torrey Bot. Cl., **75**: 512 (1948). 10) Darlington, C. D. and Wylie, A. P., Chromosome Atlas of Fl. Pl., 2nd. ed. London (1955). 11) Turner, B. L., Powell, A. M. and King, R. M., Rhodora **64**: 251 (1962). 12) Turner, B. L. and Irvin, N. S., Rhodora **62**: 122 (1960). 13) Weber, W. A., Amer. Midl. Nat., **35**: 400 (1946). 14) Battaglia, E., R. C. Acad. Lincei, Ser. 8, **2**: 63 (1947). 15) Blake, S. F., Contrib. Gray Herb., n. ser. **54**: 1 (1918). 16) ——, Contrib. U. S. Nat. Herb., **20**: 383 (1921).

Summary

Scalesia (Compositae) is an endemic genus of the Galapagos Islands. The chromosome number of *S. affinis* Hook. fil., *S. pedunculata* Hook. fil. var. *Svensonii* Howell and *S. pedunculata* Hook. fil. var. *parviflora* Howell were counted hereby as 2n=68 and their karyotypes were very alike to be expressed as K(n)=34=26V+8J. The systematic position of the genus has been referred to the subtribe Helianthinae (Verbesininae) of the tribe Heliantheae. Having the same basic number of chromosomes as $x=17$, the relationship to certain Central and South American half-shrubby species of the genera *Tithonia* and *Viguiera* of the subtribe Helianthinae is suggested. The fact that all the material examined possessed 2n=68 chromosomes, also suggests a role of polyploidization in migration and differentiation of the genus from the continent off to the Islands.

* * * *

1. *Scalesia* 属はエクアドル領ガラパゴス群島に特産するキク科の高木ないし低木で同群島産の管束植物中，最大の種数(18種)に分化している。その分類上の位置は，当初きわめて特異な属とされたこともあるが，現在ではメナモミ族のメナモミ亜族 (Heliantheae-Helianthinae) に属し，中南米産の *Tithonia*, *Wulffia*, *Wedelia* などの諸属と近縁のものとされて来た。筆者は1966年3月この群島の若干の島に立ち寄った機会に *Scalesia* 属の4つの種類の完熟した種子を採集し，うち1種を除いて発芽させることができたので，計3種類の根端細胞の核型をしらべた。

2. その結果，*Scalesia affinis* Hook. fil. (サンタクルス島アカデミー湾採集)，*S. pedunculata* Hook. fil. var. *Svensonii* Howell (同島ベラビスタ採集)，*S. ped.* var.

parviflora Howell（フロレアナ島採集）の3種類でいずれも 2n=68 を確認した。

3. 核型はいずれもよく似ていて，一次狭窄を sub-terminal にもつもの8対と，median ないし sub-median にもつもの26対で，核型式は K(n)=34=26V+8J であった。

4. 染色体の大きさは全体に小型で，最長のものでも5μ前後であった。68本の total length は3類種を通じて 190μ から 225μ であった。

5. *Scalesia* が所属するメナモミ亜族の染色体数はさまざまで，基本数も11から21にわたっている（表）。本属で n=34 が数えられたが，中南米産の近縁属中，これと同じ基本数（n=17）をもつものは *Tithonia*, *Viguiera* および *Helianthus* である。このうち，属中の全種が草本である *Helianthus* を除く他の2属中の低木となる種に *Scalesia* との系統的な類縁が考えられる。

6. *Scalesia* がいずれも 2n=68 であることから考えると，その祖先形の，大陸からこの群島への移動と分化にあたって，倍数化が大きな役割を果したことが想像される。

○高等植物分布資料（58）　Materials for the distribution of vascular plants in Japan (58)

○ヒメミミカキグサ *Utricularia nipponica* Makino　本種は自生地として豊橋市，四日市市，津市のそれぞれ郊外が知られている。以前に産し，現在は絶滅したと考えられる尾張定光寺，渥美半島を入れても，非常に限られた地域にのみ分布する小形の食虫植物である（小池常雄氏による）。1967年9月17日，名古屋市緑区鳴海町の湿地で本種の群落を見つけた。群落の大きさは約2平方米で，ミミカキグサと混生していた。この湿地はコナラ，アカマツ等の二次林からなる丘陵地の南西斜面に，湧水のためにできたものである。地表は常に湿潤で，大きな木はなく，シラタマホシクサ群落などがみられる。他の食虫植物として，ミミカキグサ，ホザキノミミカキグサ，モウセンゴケ，コモウセンゴケ，イシモチソウがみられる。終りにご教示いただいた水島正美博士，小池常雄氏に感謝します。　（名古屋市　高蔵女子商業高等学校　浜島繁隆）

○キタノカワズスゲ *Carex echinata* Murr. 北周極要素の一つで，欧亜大陸と北米の北部に広く分布している。日本では従来北海道にのみ知られ，近隣地域では千島，樺太，北鮮の湿原に普通に産するが，本州には未記録であった。国立科学博物館の日本列島調査の結果，陸中，五葉山の山地に生育しているのが判ったのは興味がある。ソビエトの学者は日本のものも含めて東亜のものは北米原産の *C. angustior* Mack. であるといい，欧州産の *C. echinata* Murr. とは果胞が小さくて脈がないかまたは殆んどない点が相違するという。日本のものもたしかに脈が顕著ではない。また日本に広く分布するカワズスゲは果胞が細長く，縁辺に細鋸歯がないので区別するが，中には少し細鋸歯のでるのもあって，これらの関係は北半球全体の豊富な材料による綜合的な研究をしなければ，決定的な結論を得ることがむづかしい。　（大井次三郎）